SHOAL MANIPULATION AS AN EFFECTIVE SOLUTION TO SITE SPECIFIC BEACH MANAGEMENT, EXAMPLES FROM THREE SOUTH CAROLINA BEACHES

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Introduction

Soft engineering solutions are the current standard for addressing coastal erosion in the US. In South Carolina, beach nourishment from offshore sand deposits and navigation channels has mostly replaced construction of seawalls and groins, which were common occurrences in earlier decades. Soft engineering solutions typically provide a more natural product than hard solutions, and also eliminate negative impacts to adjacent areas which are often associated with hard solutions. A soft engineering solution which may be underutilized in certain areas is shoal manipulation.

The South Carolina coastline is generally classified as mesotidal (Hayes 1979), though the shoreline shows strong influence from both waves and tides. South of the Grand Strand the coast is composed of barrier islands separated by ebb-dominate tidal inlets. The ebb tidal deltas of these inlets often contain millions of cubic yards of sand, generally related to the tidal prism of the inlet (Gaudiano 1998). Deltas modify waves and currents, and thus are a leading control for the shape and condition of the local coastline morphology.

Gaudiano (1998) describes ebb-tidal deltas as being in "a state of quasi equilibrium between the tidal currents building the ebb-tidal deltas and incident waves forcing the delta sands landward). As part of this equilibrium, sand periodically is released from the delta and is worked by waves landward. This episodic release of sand is termed shoal bypassing, and includes three stages (Kana et al. 1985). The first stage is the emergence of the free sand body as an offshore shoal. In the second stage, the shoal is worked by waves closer to the beach where it acts as a breakwater. When the shoal fully attaches to the beach (stage 3), sand spreads laterally by wave action, replenishing the areas eroded during stages 1 and 2. Overall, new sand is added to the system; however, temporary localized erosion associated with stages 1 and 2 of the cycle may be significant.

Ebb tidal deltas and associated shoal bypass events offer unique engineering challenges and opportunities for coastal communities. Often, erosion associated with an inlet channel or shoal bypass event becomes significant enough to warrant action. The measures necessary may involve relatively small scale projects, or large-scale projects involving significant engineering, environmental, and political action. A large-scale beach nourishment project can cost several millions of dollars and may not address the site specific cause of erosion. In these instances, projects using sand from attaching shoals may provide a cost effective and environmentally sensitive solution. This paper describes three locations in South Carolina where management of shoals either has been used, or could potentially be used to solve erosion issues.

Kiawah Island, SC

Between 1989 and 2006, the northeast end of Kiawah Island experienced two of the largest shoal bypass events observed in South Carolina. Figure 1 shows the condition of the beach in August 2009, with the approximate location of the 1989 shoreline highlighted by the blue line. The earlier shoal attached in the early 1990's and created a complete barrier-lagoon system that is currently the mature marsh on the right of the image (label 1). The second shoal attached around 1998, and continued to spread to the west through 2005 (label 2). It is currently developing into a mature marsh system similar to Area 1. Together, the shoals added ~5 million cubic yards of sand to Kiawah Island.

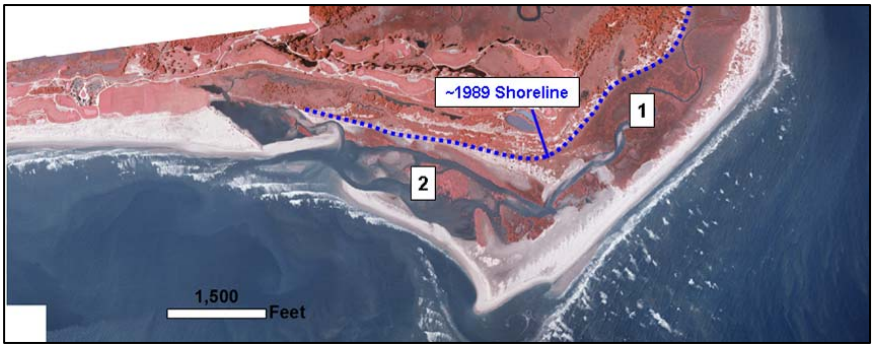

Figure 1. Kiawah Island in August 2009. Area 1 is a barrier-lagoon system created by a large shoal bypass event occurring in the early 1990's. Area 2 was created by another event occurring between 1998 and 2006.

As the second shoal bypass event progressed, a flushing channel was present at the western edge of the lagoon (Figure 2). Sediment transport was forcing the flushing channel further west, causing it to encroach on the Ocean Course, a world-renowned golf course. Beach nourishment from an offshore sand source was not considered to be a reasonable option in this instance, as there was not a sand deficit, rather the influx of sand from the shoal bypass events created the erosion issue. A project was developed to relocate the flushing channel to a position where it would not impact the Ocean Course, but would allow for the natural evolution of the barrier-lagoon system to continue. Another critical aspect of the project was to create and maintain habitat for endangered piping plovers.

The final project design involved construction of a closure dike for the original channel, excavation of the lagoon and outer beach ridge, and excavation of a new flushing channel at the junction of Areas 1 and 2. The outer ridge was excavated to prevent dune building to maintain washover habitat for piping plovers. Excavated sand was placed in the area eroded by the flushing channel. The project was constructed in 2006 via land-based equipment, and moved ~560,000 cy of sand over 1.5 months.

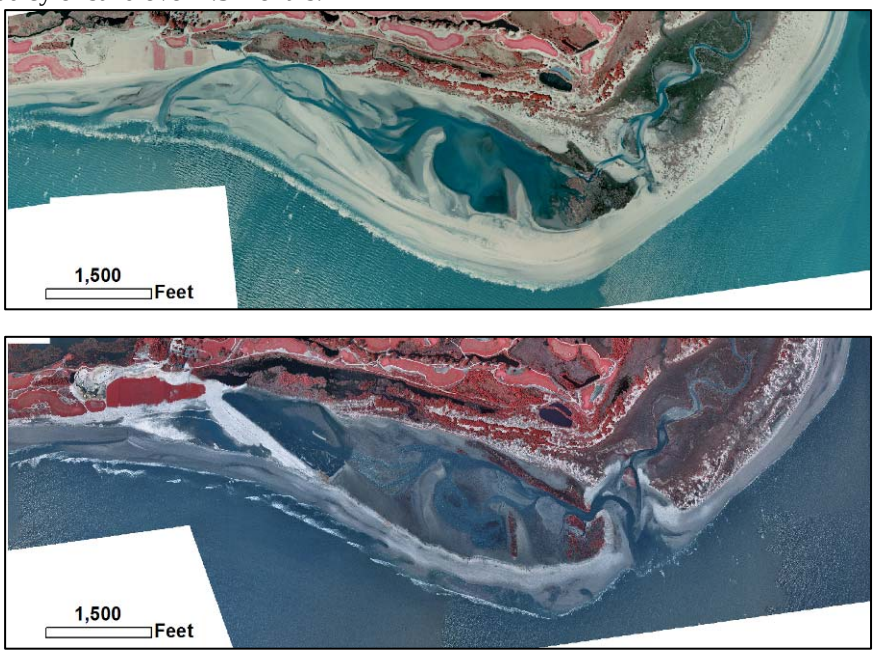

Figure 2. East end of Kiawah Island, SC before (Upper, Feb 2006) and after (Lower, Sept 2006) a sand scraping project which relocated a flushing channel and nourished an eroded area in front of the Ocean Course.

Following the project, the condition of the shoreline and the area of various habitats (marsh, washover, intertidal, etc.) has been monitored. The shoreline has continued to evolve as expected, migrating landward and infilling the marsh/lagoon (though the flushing channel did relocate to a more western position). Washover habitat has increased by ~ 50 acres and vegetated marsh by ~27 acres, relative to the pre-project condition. This shoal management

project represents a large-scale project completed in an environmentally sensitive manner. Through understanding of the natural processes causing the erosion, planners were able to provide a solution which addressed the physical troubles associated with erosion as well as the underlying cause so the problem would not continue in the near future. This project was unique in that it dealt with shoal bypass events much larger than those typical of most South Carolina beaches.

Isle of Palms

Isle of Palms, located just north of Charleston, SC, has been accretional in recent decades due to an influx of sand from shoal bypassing at Dewees Inlet at the northeast end of the island. On average, the shoal bypass interval was ~6.6 years between 1941-1997 (Gaudiano, 1998). Shoal bypass events have been well studied at Isle of Palms, and an event here in the early 1980's was used by Kana et al. (1985) to model the shoal bypass cycle. A similar event occurring between 1996 and 1998 is shown in Figure 3.

Figure 3. A shoal bypass event at Isle of Palms, SC. In the first two photos, sand from areas adjacent to the attachment site has moved to the area in the lee of the shoal, which is acting as a breakwater. Once completely attached, sand spreads into the eroded areas, naturally renourishing the beach. Erosion is usually temporary, but can be severe enough to endanger structures, requiring remedial action.

The shoal bypass events ultimately add sand to the Isle of Palms beach; however, they also temporarily cause significant erosion to areas adjacent to the attachment site. Since the northeast end is developed, it has led to several erosion control measures, including limited sand scraping, sandbagging, and nourishment from inland and offshore sources. The use of sandbags has generally been effective at protecting the structures, however have also caused environmental issues when they degrade, and do not address the cause of erosion. Likewise, nourishment via dredging manages the local sand deficit; however the nourishment sand can be quickly eroded during the next shoal bypass event. Relocating sand from the attaching shoals potentially provides a better solution to the erosion problem.

Shoal management through land based or dredging operations would offer protection for development while directly addressing the cause of erosion. An effective management strategy would act to speed the natural transition from stage 2 to stage 3 of the bypass cycle by relocating excess sand (from the attaching shoal) which is causing erosion to the eroded areas. This was done during the event pictured in Figure 3, as well as during events in the 1980, and helped accelerate the natural restoration of the beach. Incorporating the strategy into a long-range management plan would allow the community to avoid erosion crises in a cost-effective and low-impact manner.

Fripp Island

Fripp Island, in Beaufort County, SC, represents a location where small-scale sand scraping projects could be combined with an initial large-scale shoal management project to solve a long-term erosion problem. Much of the island was developed just after a large shoal bypass event added an uncharacteristic amount of sand to the beach. As the shoal sand migrated to other areas, the shoreline retreated and encroached on the development. An armor stone revetment was installed to hold the shoreline, and presently, only a small portion of the beach is healthy. One factor controlling the condition of the eastern portion of the beach is the Fripp Inlet channel, which has migrated closer to the island in recent decades. The other is sand bypassing, which builds a small area on the central portion of the island, but is not providing enough sand to maintain the beach in the position fixed by the armor-stone. Relocating

the inlet channel by dredging the shoals then using the dredged sand to build the beach would offer an initial solution to the eastern end of the island, while managing the attaching shoals would provide a long-term maintenance plan.

Conclusions

In eroded settings where adequate sediment supply exists, beach nourishment from offshore sand sources may not be the best solution for long term beach management. A better solution may be to manage available sand near the shore that is the underlying cause of site-specific erosion. Especially in areas impacted by shoal bypass events, natural process can be accelerated through engineering projects which restore eroded areas as well as reduce the severity of future erosion affecting an area. Shoal management, when engineered though an appropriate understanding of the natural processes, has been demonstrated to be a valuable tool for coastal planners.

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